International Journal of Ecosystem 2013, 3(2): 13-17
DOI: 10.5923/j.ije.20130302.01

The Influence of Intercropping Maize (*Zea mays* L.) Green Gram (*Vigna Radiata* L.) on the Changes of Soil Temperature, Moisture and Nitrogen

Mehdi Dahmardeh[1,*], Khashayar Rigi[2]

[1]Department of Agronomy, University of Zabol, Iran
[2]The former student of agronomy, University of zabol, Iran

Abstract To study of the growth and development of maize and green gram in sole and intercropping systems, an experiment using replacement techniques was conducted using different cropping systems of intercropping in five levels (sole maize, sole green gram, 25% maize + 75% green gram , 50% maize + 50% green gram, 75% maize + 25% green gram) and three cultivars of maize (S.C 260, S.C 301, S.C 302) at split plot experiment in the form of RCBD with three replications at the Research Farm of Agriculture Center of Zabol University (Iran) in 2011. Cultivars of maize were allocated to main plots and cropping systems of intercropping was allocated to sub plots. The results showed that the maximum of soil moisture was obtained at sole green gram and between intercropping the highest soil moisture was obtained in 75% green gram + 25% maize. The maximum of soil temperature was obtained at sole maize and between intercropping the highest soil temperature was obtained in 75% maize + 25% green gram. The maximum of soil N was obtained at sole green gram and between intercropping the highest soil N was obtained in 75% green gram + 25% maize intercropping. The highest LER obtained from cropping system of 75% maize + 25% green gram with LER=1.42. The highest of LER for cultivars of maize was obtained in S.C 302 (1.13). Results indicate that intercropping can increase shading in cropping system compared to sole maize, reduced water evaporation, conservation of soil moisture and improves soil fertility leading to increased crop yield. The results also showed that the best cultivar was S.C 302 and the best cropping system was 75% maize + 25% green gram from the viewpoint of LER and 75% green gram + 25% maize from the viewpoint of soil N fertility.

Keywords Intercropping, Maize, Green gram, Soil N, Soil Moisture, Soil Temperature

1. Introduction

This negative result of agricultural training could be contrary by the correct used of fram yard manures and crop residues within cropping systems[16]. Cropping system (i.e. intercropping or multiple cropping) plays an important role in agriculture because of the effective used of resources, significantly improvment crop productivity compared to that of sole cultured crops[18]. Inter specific competition and facilitation interaction which may curse when two crops are grown together have been lengthy attended[28]. Pulse crops are widely indicators as builders of soil fertility and participate substantial amounts of N for sustainability of cereal-based cropping systems. Capacity of pulse crops increases soil fertility[8]. N transfer from legumes to cereals has been lengthy studied[12]. Sharma and Gupta (2002) were indicated that puls crops are costly in improving yield and N nutrition of pearl millet[22]. Intercropping is spread accepted as a sustainable practice due to its yield advantage, high used efficiency of light and water[9, 30]. Lupwayi and Kennedy (2007) were indicated that intercropped pulse crops benefit the associated cereal crop like maize by either transferring a part of fixed N_2 because of their less N requirement[19]. Intercropping can keeping soil moisture by providing shade, reducing wind speed and improved soil structure[27]. Sillon et al. (2000) were concluded how the station of the different root systems in an intercropping system affects water uptake and the ability of each crop to compete for water resources[23]. Ghanbari et al (2010) was shown that maximum values soil moisture was recorded at 85 DAP and water contents were fewer at 95 Day after Planting. Values of soil water content under the sole maize crop were similar to those in the Cowpea-maize system. They had shown that the measured soil water contents in the sole maize system were fewer than those in the intercropping systems[7].

We attended the effect of cropping system on soil moisture, soil temperature, soil nitrogen and LER of a maize/green gram intercropping system. The assumption we

* Corresponding author:
mdahmardeh@uoz.ac.ir (Mehdi Dahmardeh)
Published online at http://journal.sapub.org/ije

tested were: (1) intercropping is better at conservation of soil moisture and temperature compared to sole maize ,(2) intercropping is better at yield advantages compared to sole crops and (3) intercropping is better at increase of Nitrogen content of soil compared to sole maize.

2. Materials and Methods

A Split plot experiment using replacement techniques was conducted using different cropping system of intercropping in five levels (sole maize, sole green gram, 25% maize + 75% green gram, 50% maize + 50% green gram, 75% maize + 25% green gram) and three cultivars of maize (SC 260, SC 301, SC 302) at split plot experiment in the form of RCBD with three replications at the Research Farm of Agriculture Center of Zabol University (Iran) in 2011. Cultivars of maize were allocated to main plots and cropping system of intercropping was allocated to sub plots. Planting dates for the cropping season 2011 was 21 April. The experiment was carried out on a sandy loam soil (Table 1).

All phosphorus (300 kg/ha) and Potassium (100 kg/ha) and half of nitrogen (175 kg/ha) were applied at planting while rest of nitrogen was applied at stem elongation stage. All other cultural practices including irrigation, thinning and weeding were kept normal and uniform for all the treatments. The treatment comprising the individual plot size was 3 m × 0.5 m. Maize cultivars include: S.C 260, S.C 301 and S.C 302 and green gram was native cultivar were sown on year 2011 by hand. Inter-row spacing was 50 cm. Initially 2-3 seeds were sown per hole. Twenty five days after sowing (25 May), seedlings were thinned to retain one healthy seedling per hole. Soil moisture dynamics were studied during 2011 year in all treatments, using of different between wet and dry soil. Sampling done of three point of treatment depth of 0- 15 cm soil. Distinct of soil volume by cylindrical ring (100 cm^3) was pick up and weight then in drier machine to 110 c^o was set. Difference of wet and dry soil weight was volume of water. Soil voluminal water calculated by below formula.

$$Q_t = V_m / V_t \cdot 100$$

That V_m is soil voluminal water, and V_t is volume cylindrical ring (100 cm^3).

The soil layer above thermometers was used to record soil temperatures. The thermometer were buried in the soil horizontally (at 20 cm depth), between two row plants in each of the maize and green gram rows in a middle row. The measurement of temperature afternoon was made on relatively clear days. The thermometer was Dial Deep Frying Model that made of France country. Nitrogen was determined by Kjeldahl procedure. Potassium was measured by flame photometer (Corning 405). The Land Equivalent Ratio (LER) was used to evaluate intercrop efficiencies in yield to sole crops. The LER defines yield as a function of area:

$$LER = ICa/MCa + ICb/MCb$$

Where IC and MC refer to intercrop and mono crop yields and the subscripts a and b indicate the component crop yields in the mixture. The data on growth, yield and other parameters were analyzed by Fisher's analysis of variance technique and Duncan test at 0.05 probability level to compare the treatment means[24] Data analyses were conducted using of SAS[21] as a Split plot experiment 5 × 3 with three replicates.

3. Results and Discussion

3.1. Soil Moisture (SM)

Analysis of variance (Table 2) showed that there were significant effects of cropping systems, cultivars and interaction cropping system in cultivars on soil moisture content (Anova).

Table 1. Soil characteristics of the experiment area during 2011 growing season

Year	Depth of soil (cm)	pH	Ec(ds /m)	N (%)	Ca(ppm)	K(ppm)	Sand	Silt	Clay
2011	0-30	7.7	8.1	0.057	11.3	241	70	16	14

Table 2. Analysis of variance for parameters of cropping systems and cultivars of maize

S.OV	df	SM	ST	SN	LER
Replication	2	16.33^{ns}	21.99^{ns}	0.00000001^{ns}	0.0001^{ns}
C	2	4.33^{**}	4.33^{**}	0.0000082^{**}	0.00077^{**}
Error (a)	4	0.0017	0.001	0.0000006	0.000066
I	4	1.87^{**}	1.8^{**}	0.000042^{**}	0.618^{**}
C*I	8	5.85^{**}	5.6^{**}	0.00000084^{ns}	0.00026^{**}
Error (b)	24	0.0016	0.001	0.00000006	0.000044
C.V (%)	---	0.17	0.10	1.97	0.59

*, **, ^{ns}:significant at $p<0.05$ and $p<0.01$ and non significant, respectively.
SM: Soil moisture, ST: Soil temperature, SN: Soil nitrogen, LER: Land equivalent ratio.
C.V: Coefficient of Variation

Table 3. Means of parameters of maize cultivars and cropping systems

Cultivars	SM	ST	SN	Total LER
S.C 260	9.38 b	25.9 a	0.040 a	1.11 b
S.C 301	9.45 b	25.1 b	0.038 b	1.12 a
S.C 302	9.93 a	24.4 c	0.038 b	1.13 a
Cropping system Maize : green gram				
100:0	9.49 d	25.4 a	0.038 e	-----
0:100	12.03 a	22.1 d	0.048 a	-----
75:25	10.04 c	24.4 b	0.041 d	1.42 a
25:75	11.26 b	23.2 c	0.046 b	1.02 b
50:50	10.52 c	23.9 c	0.044 c	0.91 c

SM: Soil moisture, ST: Soil temperature, SN: Soil nitrogen, LER: Land equivalent ratio.
Any two means not sharing a common letter differ significantly from each other at 5% probability

Soil moisture content in the soil was reduced dramatically in the sole crop of Maize due to high evaporation potential; on the contrary soil moisture content in the soil was increased dramatically in the sole crop of green gram due to low evaporation potential for growth period. green gram provided better soil cover compared to sole maize so water evaporation at soil surface was low and high soil moisture compared to sole maize. Division of root systems among species and cropping system influenced the water content down the soil profile. In the green gram-maize intercropping plots, soil water content was average between sole green gram and sole maize. Similar findings were shown by Izaurralde et al. (1994), including greater water use efficiency in a pea-barley intercropping than in either of the sole crops[10]. Improvement canopy cover is also critical to crop water-use or evapotranspiration and its partitioning between transpiration and soil evaporation[6]. Morris and Garrity (1993) were shown that increasing fertility of intercropped soybean and maize over the sole crop has been to connect with to better use of water[15]. Ogindo and Walker (2005) to study of maize-bean intercrop had shown that intercrop have been known to holding water, largely due to early high leaf area index and higher leaf area[20]. Maximum values soil moisture was recorded at S.C 302 and minimum values soil moisture was recorded at S.C 260. In summary, the measured soil water contents in the sole maize system were fewer than those in the intercropping systems.

3.2. Soil Temperature (ST)

Soil temperature (Table 2) was significantly affected by cropping systems, cultivars and interaction cropping system in cultivars. Soil temperatures may therefore effect growth and development differently, although on root temperature requirements when shade is betray noticeable less has been detection[13]. The results indicated that soil temperature in cropping systems could be developed into a functional methodology for understanding shading gradients in space. Intercropping systems was compared to sole crop of green gram have higher than soil temperature (Table 3). On the contrary the highest of Soil temperature was obtained at sole maize. The highest of ST was sole maize and the lowest ST was obtained at sole green gram and intercropping has average ST compared at both sole crops (Table 3). In addition to this, significant soil temperature reduction of intercropped compared to sole maize may also have resulted from the shading effect of the both crops (green gram and maize). One reason for observing difference between the cropping systems could be that shading effect at intercropping compared to sole maize. A significant alley cropping influence on soil temperature was reported by Monteith et al. (1991) in a semi-arid tropical region; soil temperature was always greater in the center of the alley than below the two hedges, up to 80 days after planting of pearl millet between hedges of *Leucaena leucocephala* Lam[14]. Maximum values soil temperature was recorded at S.C 260 and minimum values soil temperature was recorded at S.C 302. It is possible that S.C 302 the shading effect greater than of S.C 260 because leafs S.C 302 was greater compared S.C 260.

4. Soil N after Harvest of Maize and Green Gram Intercropping

Soil N was significantly affected by cropping systems and cultivars (Table 2). The results that the greatest soil N content and the lowest in the topsoil (0–20 cm) obtained at sole green gram and sole maize. Intercropping systems have higher soil N than sole maize (Table 3). Green gram facilitated the growth of intercropped maize and caused was obtained higher yield in intercropped than sole crops (LER>1). Reason of this high yield is possible transfer of N at intercropping of green gram to maize. There have been reports of N transfer occurring in legume/cereal intercropping[25]. Development cereals, e.g. maize in the present study, would efficiently utilize soil nitrate and thus there would be less against effect on N fixation by legumes. In pea/barley intercropping, the intercropping advantage was longer due to the perfectly use of soil inorganic and atmospheric N sources by the inter cropped pea and barley, resulting in reduced competition for inorganic N, rather than a facilitative effect, in which symbiotically fixed N_2 was made available to the barley[11]. Sharma and Gupta (2002) were concluded that pulse crops are to cost in improving yield, quality, and N nutrition of pearl millet[22]. Zheng et al (2003) indicated that the spatial and temporal differences in the growth factors and different crop species, intercropped plants could better utilize nutrients from soils compared with sole cropped plants[29]. Ghosh et al (2007) were showed that pulse crops are spread recognized as creative of soil fertility and contribute substantial amounts of N for sustainability of cereal-based cropping systems. Inclusion of legumes increases soil fertility and result the productivity of succeeding cereal crops[8].

4.1. Land Equivalent Ratio (LER)

Higher LER in intercropping treatments revealed yield advantage over sole cropping due to better land advantages. The mean LER values were always greater than 1.0 (Table 3). Advantage from non legume–legume intercropping systems have been reported anticipation in crops such as wheat and legume[1], pea and barley[3], field bean and wheat[2] and maize and faba bean[18], and maize and cowpea[4]. The highest (Land Equivalent Ratio) LER was obtained S.C 302 (1.13) and the lowest LER was obtained S.C 260 (1.11), no significant different between S.C 301 and S.C 302. LER values were greater than one in 75%mungbean + 25% maize and 75%maize+25% green gram which indicated yield advantage of intercropping over sole maize. When LER is greater than 1, the intercropping pleasing the growth. In contrast, when LER is lower than 1, the intercropping negatively affects the growth and yield of plants grown in mixtures[5, 26]. So intercropping showed an advantage over sole cropping at 75% green gram + 25% maize and 75%maize +25% green gram. Comparing partial LER values, maize was clearly the dominant component of the intercrop, displaying a considerably greater competitive ability to acquire growth limiting factors than green gram. Thus, it can be suggested that perfectible facilitation prevailing over competitive interference. Facilitative root interactions are most likely to be of importance in nutrient-poor soils and low input agro ecosystems due to critical inter specific competition or facilitation for plant growth factors[17]. Because of the spatial and temporal differences in the growth factors and different crop species, intercropped plants could better utilize nutrients from soils compared with sole cropped plants[29].

5. Conclusions

From the above it can be showed that there are moratorium for improving the productivity of green gram /maize in the southeast of Iran at the Arid ecological zone using of intercropping is the best cropping systems, because at this system improved soil moisture, soil temperature, Soil N and High yield was higher than compared to other sole crops. Variation of microclimatic in intercropping system have caused that agreeable environmental condition have ready for growth and high yield compared to sole crops. The green gram - maize intercropping operated more reserved water than a sole maize crop; the beneficial effects of the intercropping (reduced evaporation) appeared to plenty amends for interruption and uptake losses near the green gram canopy. It is obvious from the results, that green gram and green gram - maize intercropping are more effective in improving soil water keeping compared to sole maize. Facilitative root interactions are most likely to be of importance in nutrient-poor soils and low input agro ecosystems due to critical inter specific competition or facilitation for plant growth factors. We observed that intercropping of green gram and maize improved the soil focalizations of N. And then yield improvement, the facilitation of mineral nutrition of maize and green gram by intercropping improved the mineral composition of soil culture. Thus, intercropping maize and green gram was caused improved soil fertility.

ACKNOWLEDGEMENTS

We gratefully acknowledge Zabol University, Research Farm of Agriculture Center and Mr. Karimian for supporting the project.

REFERENCES

[1] Banik, P. 1996. Evaluation of wheat (Triticum aestivum) and legume intercropping under 1:1 and 2:1 row replacement series system. J. Agron. Crop Sci. 175: 189-194.

[2] Bulson, H.A.J., R.W. Snaydon, and C.E. Stopes. 1997. Effects of plant density on intercropped wheat and field beans in an organic farming system. J. Agric. Sci. 128: 59-71.

[3] Chen, C., M. Westcott., K. Neill., D. Wichman, and M. Knox. 2004. Row configuration and nitrogen application for barley–pea intercropping in Montana. Agron. J. 96: 1730-1738.

[4] Dahmardeh, M., Ghanbari, A., Syasar, B. A and Ramroudi, M. 2009. Effect of Intercropping Maize (Zea mays L.) with Cow pea (Vigna unguiculata L.) on Green Forage Yield and Quality Evaluation. Asian journal of plant science. 8 (3). pp: 235- 239.

[5] Dhima, K.V., A.A. Lithourgidis., I.B. Vasilakoglou, and C.A. Dordas. 2007. Competition indices of common vetch and cereal intercrops in two seeding ratio. Field Crop Res. 100: 249-256.

[6] Gregory, P.J., Simmonds, L.P., Pilbeam, C.J., 2000. Soil type, climatic regime, and the response of water use efficiency to crop management. Agron. J. 92, 814–820.

[7] Ghanbari, A., Dahmardeh, M., Siahsar, B. A and Ramroudi, M.2010. Effect of maize (Zea mays L.) - cowpea (Vigna unguiculata L.) intercropping on light distribution, soil temperature and soil moisture in arid environment. Journal of Food, Agriculture & Environment Vol.8 (1): 102 - 108 .

[8] Ghosh PK, Bandypadhyay KK, Wanjari RH, Manna MC, Mishra AK, Mohanty M et al (2007) Legume effect for enhancing productivity and nutrient use efficiency in major cropping systems—an Indian perspective: a review. J Sustain Agric 30(1):61–86.

[9] Hauggaard-Nielsen, H., M.K. Andersen., B. Jornsgaard, and E.S. Jensen. 2006. Field Crops Research 95:256-267.

[10] Izaurralde, R.C., D.S. Chanasyk, and N.G. Juma .1994. Soil water under conventional and alternative cropping systems in cryoboreal subhumid Central Alberta. Can. J. Soil Sci. 74, 85–92.

[11] Jensen S.1996. Grain yield, symbiotic N fixation and interspecific competition for inorganic N in pea-barley intercrops. Plant and Soil. N182. P. 25–38.

[12] Karpenstein-Machan M, Stuelpnagel R (2000) Biomass yield and nitrogen fixation of legumes monocropped and intercropped with rye and rotation effects on a subsequent maize crop. Plant Soil 218:215–232.

[13] Monteith, J. L., and M.H. Unsworth. 1990. Principles of Environmental Physics, 2nd edn. London: Edward Arnold, 291 p.

[14] Monteith, J.L., C.K. Ong, and J.E. Corlett. 1991. Microclimatic interactions in agroforestry systems. For Ecol Manage 45: 31–44.

[15] Morris, R.A. and D.P. Garrity, 1993. Resource capture and utilization in intercropping: water. Field Crops Res., 34: 303-317.

[16] Nardi, S., Morari, F., Berti, A., Tosoni, M., Giardini, L., 2004. Soil organic matter properties after 40 years of different use of organic and mineral fertilisers. European Journal of Agronomy 21, 357–367.

[17] Nielsen, H.H, and E.S. Jensen. 2005. Facilitative root interactions in intercrops. Plant Soil 274:237–250

[18] Li, L., S.C. Yang., X.L. Li., F.S. Zhang, and P. Christie. 1999. Interspecific complementary and competitive interaction between intercropped maize and faba bean. Plant Soil 212:105–114.

[19] Lupwayi NZ, Kennedy AC (2007). Grain legumes in northern plains: impacts on selected biological processes. Agron J 99:1700–1709.

[20] Ogindo, H.O. and S. Walker, 2005. Comparison of measured changes in seasonal soil water content by rained maize-bean intercrop and component cropping in semi arid region in South Africa. Phys. Chem. Earth., 30(11-16): 799-808.

[21] SAS Institute. 2001. SAS Procedure Guide. Version 8.2, SAS Inst., Cary, NC.

[22] Sharma OP, Gupta AK. 2002. Nitrogen-phosphorus nutrition of pearlmillet as influenced by intercrop legumes and fertilizer levels. J Plant Nutr 25:833–842.

[23] Sillon, J.F., H. Ozier-Lafontaine., and N. Brisson. 2000. Modeling daily root interactions for water in a tropical shrub and grass alley cropping systems. Agro forest. Syst. 49, 131–152.

[24] Steel, R.G.D., and J.H. Torrie. 1984. Principles and Procedures of Statistics. 2nd Ed. McGraw Hill Book Co. Inc., Singapore. pp: 172-178.

[25] Ta T.C. Faris M.A. Macdowall F.D.H. 1989. Evaluation of 15N method to measure nitrogen transfer from alfalfa to companion timothy. Plant and Soil.. N. 114. P. 243–247.

[26] Willey, R.W. 1979. Intercropping–Its Importance and Research Needs Part 1 Competition and Yield Advantages. Field Crop. Abstr. 32, 1–10.

[27] Young, J. 1997. Agro forestry for Soil Management. CABI / ICRAF, Wallingford, UK.

[28] Zhang F, Li L (2003) Using competitive and facilitative interactions in intercropping systems enhances crop productivity and nutrient-use efficiency. Plant Soil 248:305–312.

[29] Zheng, Y., F. Zhang., and L. Li. 2003. Iron availability as affected by soil moisture in intercropped peanut and maize. J Plant Nutr 26:2425–2437.

[30] Zhu, Y., H. Chen., J. Fan., Y. Wang., Y. Li., J. Chen., J. Fan., S. Yang., L. Hu., H . Leung., T.W. Mew., P.S. Teng., Z. Wang., and C.C. Mundt. 2000. Genetic diversity and disease control in rice. Nature 406, 718–722.